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Subject: DRAFT Dioxin Reassessment at Arkwood, Inc. Superfund Site
Risk Evaluation of Analytical Data from Decision Unit Sampling

Dear Ms Mescher:

This letter report provides a dioxin reassessment based on an evaluation of the analytical data from samples collected as part of the Decision Unit Sampling for the Arkwood, Inc. Superfund Site ("Site") in Omaha, Arkansas that occurred in October 2014. This sampling was performed as part of an effort to evaluate risk assessment compliance of the remediated Site given recent changes in the noncancer toxicity criteria for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) (IRIS, 2013; USEPA, 2009). This report presents the results of the analysis of these samples for the 2,3,7,8-polychlorinated dibenzo-p-dioxin and furan congeners, discusses the sampling and analysis issues associated with this sampling program, and compares the results to TCDD TEQ soil screening levels for industrial worker and maintenance worker scenarios.

Summary of the Decision Unit Sampling Program

The sampling was performed using a sampling plan based on the USEPA (2011) guidance for incremental composite soil sampling. Based on this guidance, the site was divided into a set of seven areas designated as separate Decision Units (DUs), and each was sampled using an the incremental sampling methodology (ISM) (USEPA, 2011). Figure 1 shows the location of each of the decision units across the Site and details regarding the sampling plan can be found in the Final Workplan For Implementation, Decision Unit Plan Sampling And Analysis (Oxford Environmental and Safety, 2014) submitted on October 9, 2014 and approved by the USEPA on October 21, 2014. A description of each decision unit is presented as follows:

- DU 1 (Uncappped Area East) is the uncapped eastern section of the Site where no treated wood storage or processing activities were conducted based on available information. This DU is approximately 1.2 acres in area, and was divided into 5 sampling units (SU) of approximately 0.25 acres each. Incremental samples of 30 increments each were collected from SU 2, 4, and 5.

- DU 2 (Capped Area) is the capped area of the site that covers all of the formerly excavated areas. This DU is the largest DU covering 82% of the site with an area of approximately 11 acres. Because of its size, this DU was divided into 44 SU of approximately 0.25 acres each and eight SU of the 44 were selected for sampling. Single incremental samples of 30 increments each were collected from SU 9, 10, 17, 19, 28, 36, and 44 while three incremental samples of 30 increments each were collected from SU 30.

- DU 3 is the northern perimeter ditch area spanning from the natural berm area on the western side of the Site to the northeastern-most perimeter adjacent to a formerly excavated and capped area. This DU is approximately 0.14 acres in area and 467 m in length. This DU was divided in half lengthwise into two SU of approximately 233 m. One incremental sample of 40 increments and one incremental sample of 41 increments were collected from SU 1 and 2, respectively.

- DU 4 is the southern perimeter ditch area that also spans from the natural berm area on the western side of the Site to the southeastern-most perimeter adjacent to a formerly excavated and capped area. This DU is approximately 0.17 acres in area and 560 m in length. This DU was divided in half lengthwise into two SU of approximately 280 m. One incremental sample of 42 increments and one incremental sample of 54 increments were collected from SU 1 and 2, respectively.

- DU 5 (Berm Area) is the sedimentation zone and basin (natural berm area) formed by the confluence of the north and south perimeter ditches. This DU is bounded to the north by the fenceline and to the south by the road. The area of this DU is approximately 28 ft x 64 ft (0.04 acres) and included only 1 SU due to its size. Three incremental samples of 32 increments were collected from this DU.

- DU 6 (Uncapped Area West) is the uncapped area of the site between the entrance and the capped area (DU #2). This DU is approximately one acre in area and was divided into 4 SU of approximately 0.25 acres each. Three SU were sampled from this DU. SU 1 covers the area of the concrete pad formerly used as a truck decontamination pad where truck tires were washed before material from the site was hauled off-site during the remediation of the Site. This SU (SU 1) was sampled using three incremental samples. Because the concrete pad is located within the area of SU 1 and a portion of DU 4 traverses SU 1, SU 1 was gridded into 49 increments. Any incremental location that fell onto the concrete pad or within the perimeter ditch was not sampled. The three incremental samples collected from SU 1 contained 39 increments, 39 increments, and 36 increments, respectively. SU 2 and SU 3 were sampled using one incremental sample of 35 increments for each.

- DU 7 (Railroad Ditch) is the railroad ditch area that receives stormwater overflow from the natural berm area of the site during exceptionally heavy rain events. This railroad ditch area is a relatively flat zone immediately downhill from the natural berm area and adjacent to the railroad tracks, with a slight grade eastward towards the railroad tunnel. The purpose of sampling over the span of this ditch area from the natural berm area to the railroad tunnel was to evaluate potential offsite PCDD/F transport that might have occurred. This DU is bound to the south by the bottom of the hillside and to the north by the railroad track ballast. Because of its size, one incremental sample of 30 increments was collected from this DU.

The samples collected from these seven decision units were analyzed using EPA Method 1613B for the seventeen 2,3,7,8 polychlorinated dibenzo-p-dioxin and furan (PCDD/F) congeners and the TCDD toxic equivalent (TEQ) concentration for each sample based on the 2005 World Health Organization toxic equivalency factors (WHO TEF) was calculated (USEPA, 2010; Van den Berg et al., 2006). The analytical summaries for each of the samples

collected from the seven DU are included in Attachment A and the TCDD TEQ concentrations for each of the samples are presented in Table 1.

Data Evaluation

Two key issues affect the interpretation of the analytical results from this sampling program.
First, due to the sample mass requirement of the ISM methodology that requires 30 g samples, and the high concentrations of 1,2,3,4,6,7,8-HpCDD and OCDD concentrations in these samples relative to the other congeners, several of the samples had HpCDD and OCDD results that were flagged "E" for having concentrations outside the high calibration limit, even after dilution, and had recoveries of the associated internal standards that were outside the control limits. Second, because of Site geology, the soil samples collected contained a significant fraction of coarse soil material that could not be analyzed due to its large size (particle sizes greater than 2 mm in size), with the samples containing a percentage of these materials ranging from 43 to 82%. These two types of issues required different adjustments to the analytical data before they could be compared to soil screening levels. These adjustments are discussed below.

Re-analysis of Select Samples Due to Analytical Issues
Two different steps were taken to evaluate and account for the HpCDD and OCDD measurements for some samples being greater than the high calibration limit and the recoveries of their associated internal standards being outside the control limits.

First, to address the issues associated with the samples that had HpCDD and OCDD concentrations greater than the high calibration limit, two samples (DU3SU1 and DU3SU2) were re-analyzed using only 1 g of sample instead of the 30 g required by the ISM methodology.

The results of the re-analysis are presented in Table 1 and the analytical summaries for the re-analyses are included in Attachment A. The TEQ concentrations for these two re-analyzed samples were 11 to 13% lower than the original sample concentrations and were not flagged for having concentrations greater than the high calibration limit. These results indicate that the TEQ concentrations for the samples that had HpCDD and OCDD that were greater than the high calibration limit may be overestimated by 11 – 13%. For the purposes of this evaluation, all of the samples that had HpCDD and OCDD flagged for being greater than the high calibration limit were not adjusted, but the TEQ concentrations for the re-analyzed samples were used instead of the original analyses for samples DU3SU1 and DU3SU2.

To account for the problems associated with the recoveries of the internal standards being out of control, three samples, DU4SU1, DU6SU2, and DU7SU1, were re-analyzed using 30 g of sample but using five to ten times the amount of internal standard. The results of the re-analysis of these samples are presented in Table 1 and the analytical summaries for the re-analyses are included in Attachment A. The recoveries of the internal standards for these re-analyzed samples are within the control limits. The TEQ concentrations of the re-analyzed samples were within 10 – 25% of the original analysis. Two samples, DU4SU1 and DU7SU1 had TEQ concentrations in the re-analyzed samples that were 19 – 25% lower than the original analysis, while one sample, DU6SU2, had a concentration 10% higher than the original analysis. The addition of more internal standard resulted in recoveries within control limits, which indicates that taking this step improved the quality of the analysis. For the purposes of this evaluation, the TEQ concentrations for the re-analyzed samples were used instead of the original analyses for samples DU4SU1, DU6SU2, and DU7SU1.

Adjustment of the TEQ Concentration for Percent of Coarse Materials

As stated earlier, because of Site geology, the soil samples collected from this Site contained a significant fraction of coarse soil material that could not be analyzed due to its large size (particle sizes greater than 2 mm in size), with the samples containing a percentage of these material ranging from 43 to 82%. Because of this, only 18 to 57% of these samples were actually analyzed and these concentrations are only related to the soil that had particle sizes less than 2 mm in particle size. Because PCDD/Fs are known to absorb to organic carbon and fine soil particles (Paustenbach et al., 2006), the measured PCDD/F concentrations in these samples only characterize 18 to 57% of the collected soil samples and are not representative of the coarser material that was not analyzed. The issue of the appropriate particle size for the sampling had been previously discussed in a previous U.S. EPA comment by Deanna Crumbling dated October 21, 2013 on the Conceptual Site Model and Proposed Decision Unit Plan report dated August 14, 2013.

To adjust for the increased amount of coarse materials in these samples, the TEQ concentrations for each sample were adjusted for the fraction of the coarse material present in the sample using the following equation:

$$Adjusted\ TEQ = (1 - CF) * TEQ_{Fine} + CF * TEQ_{Coarse}$$

Where CF is the fraction of the sample by mass that contains material greater than 2 mm in size; TEQ_{fine} is the TEQ concentration measured in the samples after the coarse material has been removed; and TEQ_{coarse} is the TEQ concentration of the coarse fraction of the sample. Table 2 presents the fraction of each sample that contains coarse material that was measured and removed from the sample prior to its analysis at the lab. Because the coarse fraction of the sample was not analyzed and it is expected that there will be no PCDD/F measurable in this material because PCDD/Fs tend to absorb to organic carbon and fine particles in soil (Paustenbach et al., 2006), one half of the lowest limit of detection for TCDD from this sampling program of 0.557 pg/g from sample DU2SU30-2 was used as the TEQ_{coarse} value. Both the unadjusted and adjusted TEQ concentration values are presented in Table 3.

This adjustment methodology is similar to the calculation of a weighted average recommended by the Technical Review Workgroup (TRW) for lead in their report *TRW Recommendations for Sampling and Analysis of Soil at Lead (Pb) Sites* (USEPA, 2000) in which they recommend evaluating the fine (<250 µm) and coarse (>250 µm) fractions of the soil sample separately due to concerns over fine particle enrichment. This document states:

> "The suggested methodology would be to sieve the entire weighed total sample; then weigh and analyze both the coarse (> 250 µm) and fine (< 250 µm) fractions and reconstruct the total soil concentration using weighted averaging, or to simply weigh and analyze only the fine fraction."

In addition, a similar method is also recommended by the U.S. EPA for adjusting the amount of soil that is available for particulate emissions due to wind erosion. In *Hazardous Waste TSDF – Fugitive Particulate Matter Air Emissions Guidance Document* U.S. EPA (1989) on page 4-11, a methodology for visually evaluating the fraction of nonerodible elements in the soil and then modifying the amount of soil available for wind erosion is presented. For this method, a fixed area of 1 m x 1 m is marked off and the area taken up by large particle size materials or nonerodible material is estimated and the subsequent particulate emission estimate is adjusted.

Calculation of Decision Unit Concentrations

For comparison with the soil screening levels developed for the Site, a Decision Unit concentration was calculated consistent with previous U.S. EPA comments dated July 18, 2014 on the Revised Conceptual Site Model and

Proposed Decision Unit Plan report dated April 29, 2014. For each Decision Unit with either more than 3 SUs or with at least one SU that had three incremental samples, the Chebyshev 95% upper confidence limit (UCL) of the mean for the Decision Unit was calculated using the following equation:

$$95\%UCL_{Chebyshev} = \bar{x} + \left(\sqrt{\frac{1}{\alpha} - 1}\right) * \frac{SD}{\sqrt{N}}$$

Where $\bar{x}$ is the average concentration for the DU, α is the Type I error and is set equal to 0.05 for a 95% confidence limit, SD is the standard deviation, and N is the number of samples included. Table 4 presents the Chebyshev 95% UCLs for each DU for which it could be calculated for both the unadjusted and adjusted TEQ concentrations.

The Decision Unit concentrations used for each DU that were compared to the soil screening levels were either the Chebyshev 95% UCL or the maximum TEQ soil concentration for the DU, whichever was lower. The unadjusted and adjusted Decision Unit concentrations for each DU are presented in Table 4. The Chebyshev 95% UCL was only used for DU 2 and DU 6 for both the unadjusted and adjusted TEQ concentrations.

Comparison To Soil Screening Levels

Currently, the Site is inactive and the only outdoor work activity that occurs at the Site throughout the year is outdoor maintenance activities, such as mowing, that occur between 10 – 15 days/year. However, the anticipated future land use for the Site as stated in the Record of Decision (ROD) is industrial. Because of this, two TCDD soil screening levels were calculated for the Site, one for a maintenance worker based on the current site activity and one for an outdoor industrial worker based on a future industrial land use.

For the industrial worker, a soil screening level for TCDD based on noncancer effects of 730 pg/g was estimated using the same methods used to calculate the interim soil preliminary remediation goals presented in USEPA (2009) but using the updated default exposure factors from USEPA (2014). For the maintenance worker, a soil screening level for TCDD based on noncancer effects of 12,100 pg/g was estimated assuming an exposure frequency of 15 days/year and using the same methodology and other exposure factors as the industrial worker. All of the exposure factors and assumptions used to estimate these two soil screening levels are presented in Table 5.

The maximum unadjusted and adjusted TEQ concentrations for each of the Decision Units were compared to the TCDD soil screening levels calculated for the industrial worker and maintenance worker scenarios and these are summarized in Table 6. Comparing the unadjusted TEQ concentrations to the industrial worker soil screening level, only Decision Unit 2 (Capped Area) has a maximum TEQ soil concentration below 730 pg/g. In contrast, only Decision Unit 6 (Uncapped Area West) and Decision Unit 7 (Railroad Ditch) had adjusted TEQ concentrations greater than 730 pg/g. None of the Decision Units had either unadjusted or adjusted maximum TEQ concentrations above the maintenance worker soil screening level of 12,100 pg/g. This indicates that, under the current exposure conditions at the site, the PCDD/F concentrations in soil at these seven Decision Units do not pose a noncancer hazard.

Signed,

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References

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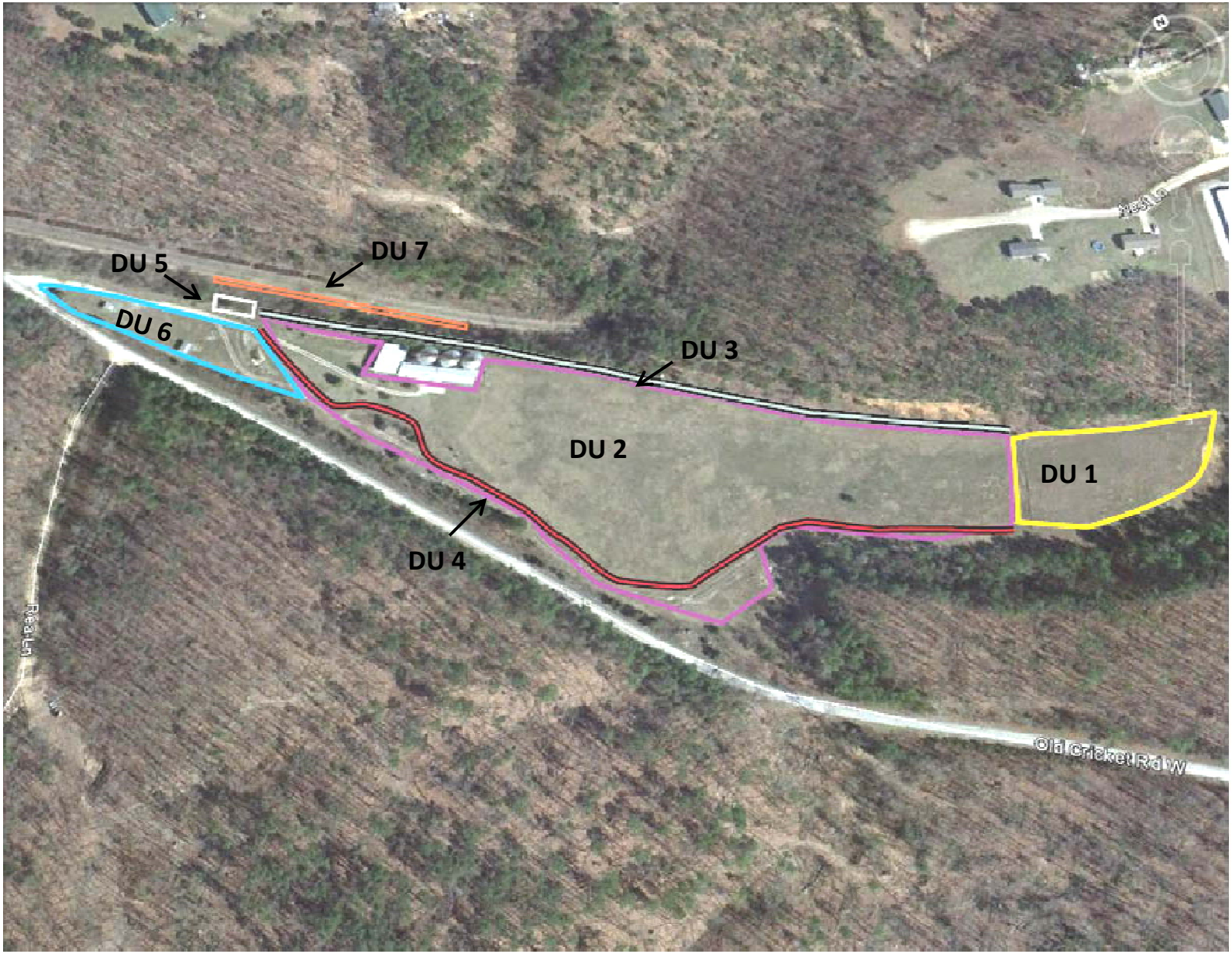
Figures

Figure 1. Overview of All Seven Decision Units



Tables

Table 1. Summary of the TCDD TEQ Concentrations from the Decision Unit Sampling.

Decision Unit	Decision Unit Name	Sampling Unit	Sample Number	TCDD TEQ Soil Concentration (pg/g)		
				Original Analysis	Re-Analysis	USEPA Analysis
1	Uncapped Area East	2	DU1SU2	379	NA	NA
1	Uncapped Area East	4	DU1SU4	1040	NA	NA
1	Uncapped Area East	5	DU1SU5	1105	NA	NA
2	Capped Area	9	DU2SU9	195	NA	NA
2	Capped Area	10	DU2SU10	60	NA	NA
2	Capped Area	17	DU2SU17	248	NA	NA
2	Capped Area	19	DU2SU19	610	NA	NA
2	Capped Area	28	DU2SU28	463	NA	288; 333[a]
2	Capped Area	30	DU2SU30-1	168	NA	NA
2	Capped Area	30	DU2SU30-2	87	NA	NA
2	Capped Area	30	DU2SU30-3	321	NA	NA
2	Capped Area	36	DU2SU36	109	NA	NA
2	Capped Area	44	DU2SU44	128	NA	NA
3	Stormwater Ditch North	1	DU3SU1-1[b,c]	545	465	NA
3	Stormwater Ditch North	1	DU3SU1-2[b,c]	509	NA	NA
3	Stormwater Ditch North	1	DU3SU1-3[b,c]	522	NA	NA
3	Stormwater Ditch North	2	DU3SU2[b]	1644	1427	NA
4	Stormwater Ditch South	1	DU4SU1[d]	1859	1502	NA
4	Stormwater Ditch South	2	DU4SU2	602	NA	NA
5	Berm Area	1	DU5SU1-1	1777	NA	1800; 1840[e]
5	Berm Area	1	DU5SU1-2	1653	NA	NA
5	Berm Area	1	DU5SU1-3	1588	NA	NA
6	Uncapped Area West	1	DU6SU1-1	1556	NA	NA
6	Uncapped Area West	1	DU6SU1-2	1568	NA	NA
6	Uncapped Area West	1	DU6SU1-3	2207	NA	NA
6	Uncapped Area West	2	DU6SU2[c]	2839	3121	NA
6	Uncapped Area West	3	DU6SU3	1771	NA	NA
7	Railroad Ditch	1	DU7SU1[c]	7325	5506	8450; 8920[f]

NA: Sample was not re-analyzed.

a Results of EPA testing from samples DF6AO and DF6A4, respectively, for DU 2 SU 28.

b Sample was re-analyzed using 1 g of sample instead of 30 g.

c Only one sample was re-analyzed and not three replicates like the original sample. The re-analysis is paired with each of the replicate samples.

d Sample was re-analyzed using an 5 - 10 times the internal standard.

e Results of EPA testing from samples DF6AO1 and DF6A5, respectively, for DU 5 SU 1.

a Results of EPA testing from samples DF6A02 and DF6A6, respectively, for DU 7 SU 1.

Table 2. Summary of Percent of Each Sample that Contained Coarse Material.

Decision Unit	Sampling Unit	Sample ID	Percent Coarse Material
1	2	DU1SU2	68.9%
1	4	DU1SU4	69.0%
1	5	DU1SU5	50.5%
2	9	DU2SU9	47.7%
2	10	DU2SU10	42.9%
2	17	DU2SU17	43.8%
2	19	DU2SU19	45.6%
2	28	DU2SU28	48.9%
2	30	DU2SU30-1	47.4%
2	30	DU2SU30-2	53.2%
2	30	DU2SU30-3	49.7%
2	36	DU2SU36	57.3%
2	44	DU2SU44	46.6%
3	1	DU3SU1-1	53.1%
3	1	DU3SU1-2	53.1%
3	1	DU3SU1-3	53.1%
3	2	DU3SU2	49.9%
4	1	DU4SU1	69.0%
4	2	DU4SU2	64.5%
5	1	DU5SU1-1	64.2%
5	1	DU5SU1-2	66.9%
5	1	DU5SU1-3	63.5%
6	1	DU6SU1-1	66.6%
6	1	DU6SU1-2	71.8%
6	1	DU6SU1-3	81.5%
6	2	DU6SU2	62.8%
6	3	DU6SU3	56.9%
7	1	DU7SU1	74.2%

Table 3. Summary of TEQ Soil Concentrations for Each Sample - Both Unadjusted and Adjusted for the Percent of Coarse Material.

Decision Unit	Decision Unit Name	Sampling Unit	Sample Number	Soil Concentration (pg/g)	Percent Coarse Material	Adjusted TEQ Soil Concentration (pg/g)
1	Uncapped Area East	2	DU1SU2	379	68.9%	118
1	Uncapped Area East	4	DU1SU4	1040	69.0%	323
1	Uncapped Area East	5	DU1SU5	1105	50.5%	547
			Average for DU 1	841	62.8%	329
2	Capped Area	9	DU2SU9	195	47.7%	102
2	Capped Area	10	DU2SU10	60	42.9%	34
2	Capped Area	17	DU2SU17	248	43.8%	140
2	Capped Area	19	DU2SU19	610	45.6%	332
2	Capped Area	28	DU2SU28	463	48.9%	237
2	Capped Area	30	DU2SU30-1	168	47.4%	88
2	Capped Area	30	DU2SU30-2	87	53.2%	41
2	Capped Area	30	DU2SU30-3	321	49.7%	162
2	Capped Area	36	DU2SU36	109	57.3%	47
2	Capped Area	44	DU2SU44	128	46.6%	69
			Average for DU 2	239	48.3%	125
3	Stormwater Ditch North	1	DU3SU1-1	465	53.1%	218
3	Stormwater Ditch North	1	DU3SU1-2	509	53.1%	239
3	Stormwater Ditch North	1	DU3SU1-3	522	53.1%	245
3	Stormwater Ditch North	2	DU3SU2	1427	49.9%	715
			Average for DU 3	731	52.3%	354
4	Stormwater Ditch South	1	DU4SU1	1502	69.0%	466
4	Stormwater Ditch South	2	DU4SU2	602	64.5%	214
			Average for DU 4	1052	66.8%	340
5	Berm Area	1	DU5SU1-1	1777	64.2%	636
5	Berm Area	1	DU5SU1-2	1653	66.9%	548
5	Berm Area	1	DU5SU1-3	1588	63.5%	581
			Average for DU 5	1673	64.8%	588
6	Uncapped Area West	1	DU6SU1-1	1556	66.6%	521
6	Uncapped Area West	1	DU6SU1-2	1568	71.8%	442
6	Uncapped Area West	1	DU6SU1-3	2207	81.5%	408
6	Uncapped Area West	2	DU6SU2	3121	62.8%	1161
6	Uncapped Area West	3	DU6SU3	1771	56.9%	764
			Average for DU 6	2045	67.9%	659
7	Railroad Ditch	1	DU7SU1	5506	74.2%	1419

Table 4. Summary of Decision Unit Concentrations Used in Comparison with Industrial and Maintenance Worker Soil Screening Levels for TCDD.

Decision Unit	Chebyshev 95% Upper Confidence Limit for Unadjusted TEQ Soil Concentration (pg/g)	Maximum Unadjusted TEQ Soil Concentration (pg/g)	Unadjusted Decision Unit Concentration (pg/g)[a]	Chebyshev 95% Upper Confidence Limit for Adjusted TEQ Soil Concentration (pg/g)	Maximum Adjusted TEQ Soil Concentration (pg/g)	Adjusted Decision Unit Concentration (pg/g)[a]
1	1647	1105	1105	759	547	547
2	435	610	435	231	332	231
3	1538	1427	1427	773	715	715
4	NC	1502	1502	NC	466	466
5	1865	1777	1777	678	636	636
6	3065	3121	3065	1145	1161	1145
7	NC	5506	5506	NC	1419	1419

NC: Not calculated because the number of samples was <3.

a This value is the lower of the Chebyshev 95% UCL and the maximum concentration for the DU.

Table 5. Comparison of TCDD Soil Screening Levels based on Industrial Worker and Maintenance Worker Exposure Scenarios

Exposure Factor	Industrial Worker	Maintenance Worker	Reference
Target Hazard Index	1	1	USEPA (2009)
Soil Ingestion Rate (mg soil per day)	100	100	USEPA (2014)
Conversion Factor (10^{-6} kg per mg)	1.00E-06	1.00E-06	USEPA (2009)
Oral bioavailability	1	1	USEPA (2009)
Surface Area of Exposed Skin (cm^2)	3470	3470	USEPA (2014)
Soil Adherence Factor (mg per cm^2 - event)	0.12	0.12	USEPA (2014)
Event Frequency (events per day)	1	1	USEPA (2009)
Skin Absorption Factor (unitless)	0.03	0.03	USEPA (2009)
Exposure Frequency (days per year)	250	15	USEPA (2014) for Industrial Worker; Maintenance worker mows site between 10 - 15 times per year
Exposure Duration (years)	25	25	USEPA (2014)
Body Weight (kg)	80	80	USEPA (2014)
Averaging Time - cancer (days)	25550	25550	USEPA (2009)
Averaging Time - noncancer (days)	9125	9125	USEPA (2009)
TCDD Chronic RfD (mg/kg-d)	7.00E-10	7.00E-10	IRIS (2012)
Combined screening level (ng/kg)	730	12100	

Table 6. Comparison of Samples by Decision Unit to Industrial and Maintenance Worker Soil Screening Levels for TCDD.

Decision Unit	Unadjusted Decision Unit Soil Concentration (pg/g)	Below Industrial Worker Soil Screening Level of 730 pg/g?	Below Maintenance Worker Soil Screening Level of 12,100 pg/g?	Adjusted Decision Unit Soil Concentration (pg/g)	Below Industrial Worker Soil Screening Level of 730 pg/g?	Below Maintenance Worker Soil Screening Level of 12,100 pg/g?
1	1105	No	Yes	547	Yes	Yes
2	610	Yes	Yes	231	Yes	Yes
3	1427	No	Yes	715	Yes	Yes
4	1502	No	Yes	466	Yes	Yes
5	1777	No	Yes	636	Yes	Yes
6	3121	No	Yes	1145	No	Yes
7	5506	No	Yes	1419	No	Yes

Attachment A

The lab sheets for the analytical data can be found at:

https://chemrisk.egnyte.com/SimpleUI/home.do#Files/0/Shared/Arkwood/Analytical%20Data